US Ecology Idaho Request for Class 3 Permit Modification

Radiological Safety Assessment

May 2019

Table of Contents

1.0 Scope of Proposed Permit Modification

US Ecology Idaho (USEI) respectfully requests Modification to its Part B permit to include the following program elements:

- Replace the generic RESRAD radiological modeling platform with a customized Site-Specific Performance Assessment created on the GoldSim modeling platform;
- Increase the allowable concentration for Ra-226+Ra-228 and Pb-210 in Waste Acceptance Criteria (WAC) Table C.2 to 10,000 pCi/g for all received waste (regardless of packaging);
- Increase the allowable radionuclide concentrations in WAC Table C.4b and C.4c to 10,000 pCi/g;
- Update footnote language in WAC Tables C.4b and C.4c to be consistent with other proposed WAC changes;
- Remove radioactive liquids definition from permit as well as 40 microRoentgen per hour (µR/hr) dose rate limit on received radioactive liquids in procedures ERMP-01 and ERMP-05; and
- Clarify and simplify language throughout ERMP procedures.

Details pertaining to each of the individual items are presented in the Sections to follow.

2.0 Replacement of RESRAD Model with GoldSim Platform

2.1 Need for Radiological Model Replacement

The Residual Radioactivity modeling code (RESRAD) has been part of the USEI Part B permit since 2005. RESRAD is a publicly available radiological modeling platform developed by Argonne National Laboratory (ANL) designed to estimate potential radiation doses to hypothetical individuals from radioactive materials disposed below ground surface. RESRAD does allow site-specific fate and transport parameters to be input into the code as a means for customizing models to be as close to actual conditions as possible. Although RESRAD was not specifically designed for use with landfills, USEI found the code to be robust enough at the time to simulate the postulated future environmental performance of the USEI landfill cells well enough to support expansion of the radiological program.

Although RESRAD does support customization of the code input parameters for site-specific analysis, it only allows limited customization of the environmental pathways used to calculate dose to future residents. For example, RESRAD will only evaluate dose from the pathways embedded in the code as delivered from ANL. If a site has been evaluated to have a potential dose pathway identified in its Conceptual Site Model (CSM) that is not already included in RESRAD, the user has no choice but to either try and develop a separate dose assessment for that pathway or worse, simply ignore it.

Another weakness of the RESRAD code pertains to the level of built-in conservatism associated with the input parameters and pathway calculations built into the code. This is acknowledged in the RESRAD User's Manual as:

> *"The models and input parameters described in this manual and incorporated into RESRAD have been chosen so as to be realistic but reasonably conservative, and the calculated doses corresponding to guideline values of the radionuclide concentrations are expected to be reasonably conservative estimates (overestimates) of the actual doses."*

The design of the RESRAD code as inherently conservative is not a flaw since it was principally designed to be used to evaluate the impact of residual radioactivity on properties either before (or after) a remedial event. The use of conservative fate and transport assumptions is typically considered acceptable under the application of the 'As low as reasonably achievable (ALARA)' standard. This was also observed to be true by USEI during the first ten years of applying RESRAD to its landfill cells. Although the inherent conservatism in the RESRAD model did predict post-closure doses that were higher than otherwise expected, it did not significantly hinder or restrict USEI's operations. From 2005 through 2012, USEI was able to expand its capabilities and grow its radiological business while using the RESRAD platform to define the underlying safety basis.

The limitations of the RESRAD code, as applied to radiological disposal scenarios, started becoming clear to USEI as part of the U.S. Nuclear Regulatory Commission's (NRC) review of alternate disposal authorization applications for the Westinghouse Hematite site. Although USEI was successful in obtaining approval for four (4) alternate disposal requests from the Hematite site, the NRC placed significant restrictions on those approvals based on (a) the radionuclide content of the Westinghouse waste, and (b) the results of USEI's RESRAD model for those radionuclides. The offending radionuclide in the Hematite waste was technetium-99 (Tc-99), a highly-soluble fission product. The USEI RESRAD model is particularly sensitive to highly soluble radionuclides like Tc-99 due to multiple layers of conservative assumptions built into RESRAD by ANL. Most notably:

- RESRAD assumes that all modeled sites have water infiltration through the top surface of the modeled contamination zone. Although the infiltration rate can be reduced through parameter input, it cannot be turned off. This assumption does not accurately represent arid sites like USEI where lysimeter data has proven that surface water does not penetrate ground surface more than approximately twelve inches (12"). (DBSA 2010)
- If the groundwater ingestion pathway is turned "ON" in RESRAD (which the USEI model does), the transport calculations for the groundwater pathway will not allow for disabling the flow to the site's defined aquifer. The only option to the user is to retard the flow of the partitioned radionuclide to the aquifer, meaning that the time required to reach the aquifer is only extended and cannot be eliminated.

The effect of these points on the Hematite dose assessments was profound since the NRC limited the total Tc-99 source term that USEI could receive from Westinghouse based on these overly conservative modeling results. USEI has been aware of the limitations being placed on USEI by the RESRAD code and considered submitting a permit modification request to turn the groundwater pathway "OFF" in the USEI model. Even though this solution would have provided short-term relief from a portion of the inherent conservatism within RESRAD, it would still be ignoring many other parts of the code that also do not accurately reflect how the Grand View site actually performs. For these reasons, USEI decided to abandon the RESRAD code in favor of a site-specific performance assessment built on the state-of-the-art radiological modeling platform called GoldSim.

2.2 Overview of GoldSim Platform

USEI hired Neptune and Company, Inc. (Neptune) to design and develop a new site-specific performance assessment (SSPA) for USEI. Neptune is a recognized expert in developing performance assessments for radioactive disposal facilities, especially within the GoldSim modeling system. "*The GoldSim probabilistic system modeling software (available from GoldSim Technology Group LLC at www.goldsim.com) is used to build the system-level computational model. GoldSim allows more flexibility and site-specificity than other modeling tools like RESRAD. GoldSim includes dynamic and probabilistic modeling capabilities and is commonly used by commercial and government-owned regulated disposal facilities.*" (Neptune 2016) Specifically, Neptune has developed SSPAs at two of the four operating low-level radioactive waste (LLRW) disposal sites in the US (Energy Solutions in Clive, Utah and Waste Control Specialists in Andrews, Texas) as well as at the DOE LLW site at the Nevada National Security Site in Mercury, Nevada.

USEI sought to leverage Neptune's vast experience modeling radioactive waste disposal facilities to obtain the most accurate and appropriate performance assessment for USEI. It also provided an opportunity to model the USEI facility using a state-of-the-art platform (GoldSim) that has already been shown to meet stringent quality and performance requirements by the US NRC for use at licensed LLRW disposal facilities and by the US DOE for use at their internal disposal facilities.

2.3 Summary of New USEI Radiological Model

The new SSPA model developed for USEI integrates the processes associated with the natural and engineered barriers that make up the RCRA-designed landfills, the fate and transport of radionuclides in the surrounding environment, and potential exposures to humans in the future. The SSPA model takes into account those features, events, processes, and exposure scenarios that are relevant to USEI, and produces estimates of future potential radiological doses that can be compared to performance metrics specified by IDEQ in our Part B permit. The SSPA is transparent in its calculations and methods, providing a defensible basis for decision making by site operations and easy verification by regulators.

The overall objective of the SSPA is to develop a more realistic and defensible model of landfill performance, environmental fate and transport, and potential human exposures related to the disposed radioactive wastes at the Site. Specific objectives include:

- Developing radionuclide inventory estimates for each modeled disposal cell.
- Improving on the modeling of radionuclide transport and dose in the current RESRAD model, focusing on a more site-specific and accurate representation of potentially complete environmental transport and exposure pathways.
- Quantitatively accounting for uncertainty in the assessment of system performance in order to better support decision making.

Neptune developed a CSM for the USEI site (see Appendix A), which forms the basis for the GoldSim computer model. (Neptune, 2016) The CSM focuses on how radionuclides disposed at USEI may be transported within disposed wastes and the surrounding environment over time, and how people may be exposed to and affected by radionuclides after disposal operations have ceased and the site is closed. Important aspects of the CSM include the characterization of the radionuclide inventory, the natural physical attributes of the environmental setting, the engineered attributes of the disposal units or cells (the permitted landfills), and an understanding of likely future human land use and activities. A flow diagram describing the features, events and processes that feed the new SSPA model is provided in Figure 1.

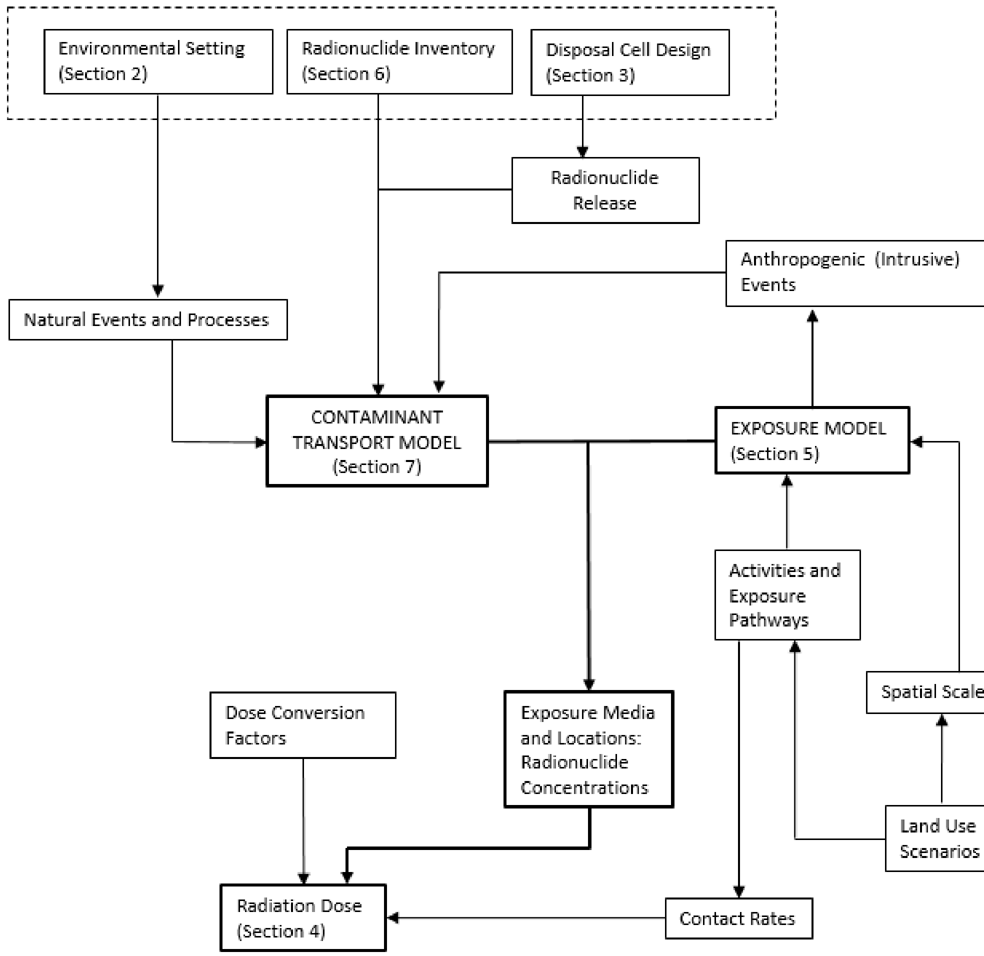

Figure 1. Diagram of the features, events and processes that go into the new USEI SSPA. (*Section Numbers in the Figure Refer to the Conceptual Site Model Document*, [Neptune 2016])

2.3.1 Model Dose Pathways

Neptune's analysis of the USEI site and surrounding community of Grand View and Southwest Idaho, in general, resulted in a collection of reasonable dose pathways to future members of the public. Neptune summarized the pathway analysis in the CSM document produced for USEI:

> *"The conceptual exposure model is divided into subsections of exposure scenarios related to non-intrusive and intrusive land use activities. Non-intrusive land use activities are those that do not involve disturbance of the disposed wastes by human activities. Under the non-intrusive scenarios, exposure to radionuclides is a function solely of natural processes (for example, erosion, diffusion, and root uptake by native plants) that can result in radionuclides migrating into environmental media (exposure media) that are contacted by people. Exposure to the radionuclides in disposed waste itself may occur through intrusive scenarios as well, in which receptor activities result in direct exposure to the waste and/or the release of waste into the environment. Examples of such activities include drilling a domestic water well or excavating a basement for a building. Intrusive activities such as these presume that institutional control of the closed disposal*

> *facility has been lost and that individuals are unaware of the existence or hazard of disposed waste."* (Neptune 2016)

Non-intrusive land use activities include ranching and recreational activities such as all-terrain vehicle riding, hunting, and target shooting. Intrusive land use activities are associated with postulated 'Inadvertent Human Intruder' (IHI) scenarios as defined by the NRC for purposes of licensing LLRW disposal facilities. While it is acknowledged that USEI is not a licensed LLRW facility, IHI scenarios were included in the USEI site-specific performance assessment since USEI frequently requests license exemptions from NRC to allow alternate disposal of licensed materials under 10 CFR 20.2002. Inclusion of IHI dose assessments in the USEI SSPA makes the exemption request reviews by the NRC easier. The IHI scenarios evaluated in the new USEI model include:

- **Intruder Drilling** – the intruder drills into the waste and brings contaminated cuttings to the ground surface
- **Intruder Discovery** – the intruder encounters buried waste during underground construction activities and recognizes them as "non-native materials."
- **Intruder Construction** - the intruder encounters buried waste during underground construction activities and does not recognize it, thus continuing on with construction.
- **Intruder Agriculture (Residence with Garden)** – Assumes a person is living in a constructed dwelling, including gardening in contaminated soils.

Details pertaining to all non-intrusive and intrusive exposure scenarios and how GoldSim was programmed to calculate doses are provided in the CSM Document developed by Neptune (see Appendix A). An analysis of the hydrogeologic setting of USEI was compiled in a Groundwater White Paper by Neptune. This analysis reached a conclusion that a groundwater ingestion pathway does not exist for USEI based on groundwater well sampling data as well as several historical groundwater studies that have been performed (Neptune 2017). The Groundwater White Paper is provided in Appendix B. A summary of all exposure scenarios developed for the USEI site are shown in Figure 2.

As Figure 2 shows, the exposure routes were modeled differently for portions of the USEI site based on design and construction differences of Cells 14, 15, and 16 as well as changes in waste placement operations for low-activity radioactive wastes. Some of the variations between the cells that resulted in unique or modified modeling include:

- A change in the 'clean cover' thickness over emplaced low-activity radioactive waste (LARW) as part of USEI's July 2009 permit modification approving increases in radium isotope concentrations. Prior to 2009, LARW was placed under 3.6m of non-radioactive waste and cover materials implemented as part of 2005 site-specific RESRAD MOD. This change in waste placement operations caused Cell 15 to have a portion of LARW under 3.6m of clean cover and the remainder under 6m. Neptune programmed the GoldSim model to accommodate this variation. Cell 14 was programmed to have 100% of its LARW under 3.6m, while Cell 16 was programmed to have 100% of its emplaced LARW under 6m.
- The IHI analyses for Cell 16 include the Discovery, Construction, and Residential portions of the analysis because the northwest corner of Cell 16 is the only place on site where adequate water exists to potentially sustain a future resident. Therefore, the IHI analyses for Cells 14 and 15 only contain assessments for the driller scenario and waste displacement associated with cutting a road into the closed landfills to facilitate ascending the finished landscape.

		Cells 14, 15 and 16		**Cell 14, 15 or 16**		**Cell 16 only**		
		Exposure Scenarios						
		Non-intrusive		**Intrusive**				
Exposure Media	**Exposure Routes**	**Recreation**	**Ranching**	**Driller**	**Construction; Road Cut**	**Construction; Residence**	**Discovery**	**Resident**
Soil	Ingestion, External	×	×			×	×	×
Outdoor air	Inhalation	×	×			×	×	×
Indoor air	Inhalation							×
Garden produce, small livestock	Ingestion							×
Livestock and game	Ingestion		×					
Waste (direct)	Ingestion, External				×	×	×	
Waste (mud pit)	External	– [2]	– [2]	×				– [2]
Off-site soil[1]	Ingestion, External	×	×					×
Off-site outdoor air[1]	Inhalation	×	×					×

[1] Evaluation contingent on magnitude of results for on-site exposures.

[2] Migration of radionuclides left in a covered mud pit from prior drilling activities is also evaluated using transport processes applicable to the cover.

Figure 2. Summary of exposure scenarios, media and routes for new USEI GoldSim model (from USEI CSM).

2.3.2 Modeled Waste Inventory

The new SSPA model for USEI has been programmed with multiple radionuclide disposal inventories so that model run results can be compared to a variety of landfill performance criteria or used for specific reporting requirements. The inventory options programmed into the USEI SSPA model include:

- Disposed Inventory (based on waste receipts) – This model inventory is an actual accounting of the LARW inventory USEI has received from customers between the years 2000-2015. The total inventory is apportioned in the model between Cells 14, 15 and 16 based on both time information (cell open date, cell closure date, other considerations) and USEI LARW receipt volumes. The breakdown of the actual radionuclide inventory in the individual disposal cells are shown in Table 1.

Table 1. Breakdown of USEI Actual Disposed LARW Inventory Percentage by Disposal Cell

Cell	2000 - 2009	2010 - 2015	2016 - present	Notes
Cell 14	0.26	0	0	LARW was received in Cell 14 starting in 2000. Starting in 2010, all LARW was being placed in Cell 15 (and subsequently Cell 16).
Cell 15	0.74	0.82	0	Cell 15 opened in 2002 and LARW receipts began immediately. LARW disposal was diverted exclusively to Cell 16 starting in 2016.
Cell 16	0	0.18	1.00	Cell 16 opened in 2014 and LARW receipts began immediately. Post 2016, 100% of USEI LARW receipts are being placed in Cell 16.

- Safety Basis Inventory (same as RESRAD model) - The Safety Basis inventory represents a historical baseline set of radionuclide concentrations that were first introduced in the 2005 site-specific RESRAD MOD. The inventory consists of 65 radionuclides with varying concentrations assumed at the time to represent what a potential USEI post-closure LARW inventory could look like. This postulated inventory serves as a ‘guidepost’ in GoldSim and is used for direct comparisons with the legacy RESRAD model (see Section 2.4). For this inventory scenario, radionuclide concentrations are assigned to the entire disposal cell volume. That is, applied uniformly from a depth of 3.6 meters to the bottom of the waste volume in Cells 14 and 15 and is applied uniformly from a depth of 6 meters to the bottom of the waste volume in Cell 16. There are no ratios used to split up the Safety Basis Inventory. All Cells are uniform in their concentrations.
- Unit Inventory – This inventory has standardized radionuclide concentrations of 1 pCi/g entered for each radionuclide as a means for developing “dose-to-source ratios” (DSR) for each radionuclide in units of millirem per picocurie per gram (mRem/pCi/g) to assist with determination of the new proposed WAC (see Section 3.0). The calculated dose results in GoldSim are linear and scalable once DSRs are calculated. For example, if the calculated DSR for Nuclide X shows that 1 pCi/g within the USEI landfills yields a peak dose of 1 mRem/yr, then USEI could sustain an overall average concentration of 15 pCi/g over the volumes of all landfills before the 15 mRem/yr post-closure dose limit would be exceeded. Evaluations like these were performed for all radionuclides in the USEI Safety Basis Inventory as part of the new WAC determination.
- Candidate Waste Inventory - Neptune also programmed a customizable “Candidate Waste Stream” inventory option into the USEI SSPA model. This module allows USEI to run

performance assessment analysis on smaller volume scenarios such as project-level waste streams or for a set of annualized waste receipts. This module is important for USEI because the NRC often requires a project-level dose assessment as part of a §20.2002 Alternate Disposal Request. The Candidate Waste Dashboard in the SSPA model allows the user to enter waste disposal area, waste thickness and a specific radionuclide inventory for an independent dose assessment.

2.3.3 Landfill Cap Considerations

The USEI SSPA model has been designed to accommodate runs using either an engineered RCRA cover design or an evapotranspiration (ET) cover. The user can select the desired cover design on the USEI model dashboard as part of any model run. This flexibility was built into the USEI SSPA model since at the time of production, no final cover decision had been made for all disposal cells.

All design parameters for each cover design were taken directly from the USEI permit documentation. (DBSA 2010)

2.4 Comparison of RESRAD vs GoldSim for USEI

2.4.1 Model Design and Capabilities

As discussed earlier in this document, the RESRAD computer code was used to perform a radiological safety assessment as part of USEI's Site B Hazardous Waste Treatment, Storage, and Disposal Permit (USEI 2009). Although the safety assessment was intended to be a conservative screening of post-closure radiological doses, the scope of the RESRAD safety assessment was limited by the pathway analyses available within RESRAD. A comparison of the pathways evaluated in the RESRAD model with those developed within the SSPA model is provided in Table 2.

As initially discussed in Section 2.0, the development of a SSPA model in GoldSim has allowed USEI to more accurately model the Grand View site with all applicable radionuclide transport pathways and exposure routes, not just those pre-programmed into the off-the-shelf RESRAD code. Neptune utilized site-specific information as well as knowledge gained through SSPA development at other arid waste disposal sites to develop the list of exposure pathways shown in Table 2. The SSPA will allow evaluation of exposure pathways specific to desert environs like those seen in the Owyhee Desert near Grand View for the first time. Exposure scenarios specific to the IHI scenarios have also been built into the SSPA model, alleviating the need to run separate workbooks in Microsoft Excel to evaluate those pathways.

A summary of all parameters programmed into the USEI SSPA model is provided in Appendix C - *Modeling Input Parameters for the Grand View PA Model v1.1*. (Neptune 2018) Neptune performed a sensitivity analysis on the SSPA model inputs and is included as Appendix E - . The Sensitivity Analysis "facilitates the identification of model inputs that explain most of the variation in the endpoints of interest, even when the inputs vary simultaneously across model runs." (Neptune 2018)

Table 2. Comparison Between Historical USEI RESRAD Model and GoldSim Site-Specific Performance Assessment Model.

Transport pathway (Exposure route)	**RESRAD**	**SSPA**
Infiltration to groundwater	×	–[1]
Drinking water	×	–[1]
Garden irrigation and livestock	×	–[1]
Irrigation → soil (ext, soil ing, produce, dust inh)	×	–[1]
Cover erosion—sheet and rill erosion	×	×
Reduced cap thickness (radon inh)	×	×
Cover erosion—gully erosion		–[2]
Exposed waste (ext); locally enhanced infiltration		–[2]
Gas-phase diffusion	×	×
Radon inhalation	×	×
Deposition of ^{222}Rn decay products in cover (ext, soil ing, produce, dust inh)		×
Water-phase diffusion		×
Radionuclides in cover (ext, soil ing, produce, dust inh)		×
Plant root uptake by native plants		×
Deposition on ground surface (ext, soil ing, produce, dust inh)		×
Ingestion by cattle (meat ing)		×
Animal burrowing		×
Mixing of cover material (ext, soil ing, produce, dust inh)		×
Human intrusion (Cell 16: drilling of a water well)		×
Cuttings on surface or in mud pit (ext, soil ing, produce, dust inh)		×
Human intrusion (Cell 16: excavation for a residence)		×
Direct exposure to waste; subsequent exposure to excavated cap material (ext, soil ing, dust inh)		×
Human intrusion (road cut on the side of a cell)		×
Road cut material on road and side slope (ext, soil ing, dust inh)		×

ext = external radiation
ing = ingestion
inh = inhalation
[1]Radionuclide transport to groundwater due to infiltration of water through disposed wastes is an incomplete pathway. See CSM (Appendix A) and Groundwater White Paper (Appendix B)
[2] The likelihood of gully formation has been evaluated and found to be negligible. See CSM in Appendix A.

2.4.2 Results of GoldSim Performance Assessment vs RESRAD for USEI

The RESRAD model for USEI as designed and implemented in 2005 predicted that future residents of the USEI site would be exposed to radionuclides from two dominant transport pathways: groundwater ingestion and radon inhalation. The 2005 model predicted a maximum dose of 9.77 mRem/year at year

247 post-closure[1]. The list of the key radionuclides and their contributions to the total dose is shown in Table 3.

Table 3. Summary of Dose Results for USEI's 2005 RESRAD Model

Nuclide	RESRAD Model Input Conc.[1] (pCi/g)	Landfill[2] Inventory at Input Conc. (Ci)	RESRAD Dose at Peak Year[3] (mRem/yr)	% of Total Dose
I-129	0.01	0.047	5.63	57.6%
C-14	10	47.43	0	0.0%
Tc-99	1	4.74	1.94	19.8%
Ra-226 (Rn-222)	112	531	1.98	20.3%
Th-230	83	394	0.22	2.3%
Th-232	28	133	5.03E-14	0.0%
U-238	83	394	1.04E-07	0.0%
		Totals	*9.77*[4]	*100.0%*

Table Notes:
1. Represent "Safety Basis Concentrations" for the nuclides shown.
2. Only represents the volume of the chosen landfill "virtual cell" in the 2005 RESRAD model (88,221m^2 with a depth of 33.6m).
3. Peak Dose in RESRAD Model occurs at year 247 post-closure.
4. Annual post-closure dose limit in USEI's permit is 15 mRem/yr.

The radionuclide inventory used in the 2005 RESRAD model is what is referred to as the "Safety Basis Inventory," which was an estimate of average concentrations of radionuclides expected in USEI's landfills at closure. These concentrations were educated guesses by USE staff based on historical trends. To allow direct comparisons with the new SSPA model, the exact same "Safety Basis Inventory" has been programmed into GoldSim, as discussed in Section 0.

The results in Table 3 highlight the relative importance of the groundwater pathway to the RESRAD model for USEI. Nearly eighty percent (80%) of the estimated peak dose at year 247 post-closure is derived from highly mobile radionuclides Iodine-129 (I-129) and Tc-99. Neither is a prominent radionuclide in USEI's current disposed inventory nor are they targets of large future business. USEI does have a current inventory of Tc-99, specifically from the Westinghouse Hematite project, but that current inventory is only approximately 1 Curie (Ci), or ~25% of the programmed RESRAD inventory.

Table 4 summarizes the results of the GoldSim SSPA. A total peak dose of 0.23 mRem/yr is estimated at year 1000 post-closure. The lower calculated dose, as compared to RESRAD, is primarily attributed to a lack of a groundwater pathway at USEI as well as proper attribution of the clean cover thicknesses for the actual landfills containing radioactive materials at USEI (Cells 14, 15 and 16). The larger RESRAD Rn-222 dose is attributable to the use of a 3.6m cover thickness for the RESRAD virtual disposal cell, whereas the SSPA Model employs the actual 6.0m thickness of material overlying radium-containing disposed wastes in all of Cell 16 as well as a portion of Cell 15 (Neptune 2018). Radionuclide transport (and subsequent dose drivers in the SSPA model) are upward (towards the ground surface) due to the

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[1] Post-closure in the context of the models means the time period that begins when all controls fail at the site and members of the public have uncontrolled access.

site's evapotranspiration potential. Upward pathways in the SSPA model include plant uptake, transport of radiological materials by burrowing animals, and gas-phase diffusion of radon.

The relative proportions of the key radionuclides driving total dose in the SSPA model are similar to the RESRAD model, with Ra-226, Tc-99, I-129 and C-14 contributing the most dose, respectively.

Table 4. Summary of Dose Results for USEI's 2018 GoldSim Model, On-site Resident Scenario

Nuclide	GoldSim Model Input Conc. (pCi/g)	Landfill[1] Inventory at Input Conc. (Ci)	GoldSim Dose at Peak Year[2] (mRem/yr)	% of Total Dose
I-129	0.01	0.29	1.0E-03	0.4%
C-14	10	293	1.1E-03	0.4%
Tc-99	1	29	7.6E-02	31.3%
Cl-36	0.1	2.93	1.6E-03	0.7%
Ra-226 (Rn-222)	112	3281	1.6E-01	67.2%
Th-230	83	2432	6.4E-10	0.0%
Th-232	28	820	1.6E-10	0.0%
U-238	83	2432	9.2E-09	0.0%
		Totals	*2.3E-01*	*100.00%*

1. Includes all active landfill cells (14, 15, & 16) with actual dimensions.
2. GoldSim Peak dose occurs at 1000 years post-closure to the Cell 16 onsite resident.

Figure 3 displays the results dashboard of the SSPA model. Primary contributors to the total dose are shown with their peak dose and time of peak.

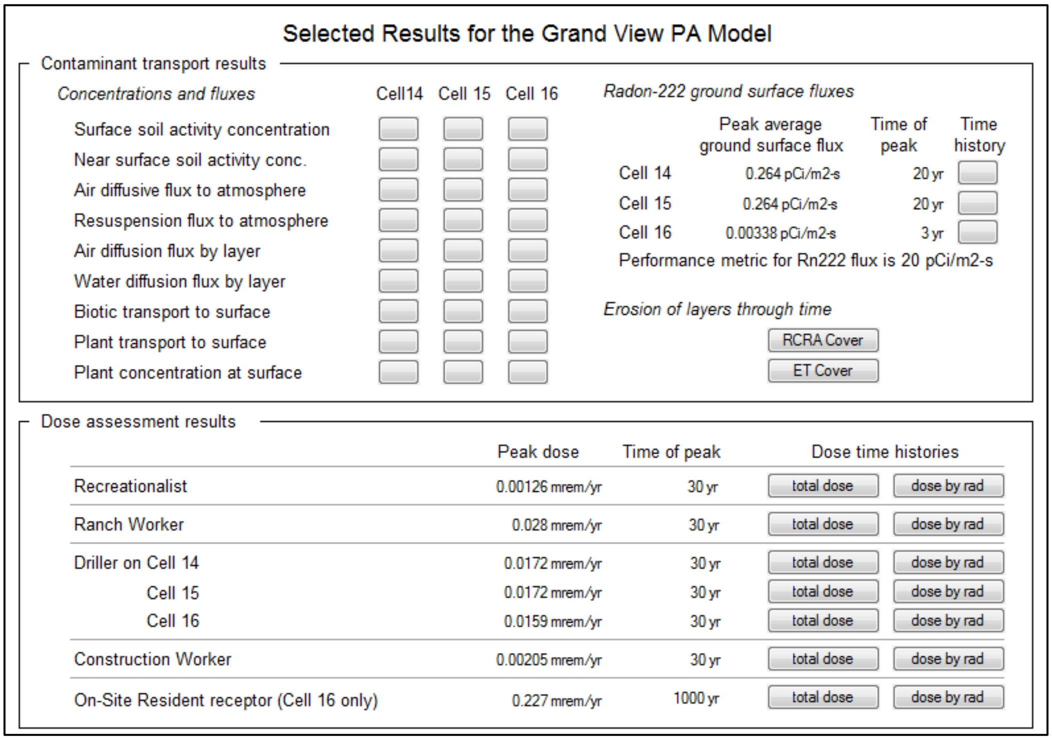

Figure 3. GoldSim Dashboard Results

Figure 4 charts dose over time for each isotope in the SSPA Cell 16 On-Site Resident scenario. Radon dose is shown to peak at 30 years post-closure, or loss of institutional control, and remains largely constant until year 1000. Dose from Tc-99 increases over time as material is transported to the surface and cover erosion occurs over time. Due to the scale of the Y-axis, the doses from C-14 and I-129 are not visible on the plot. The plot was truncated at Year 1000 since that is the required post-closure performance period in RCRA.

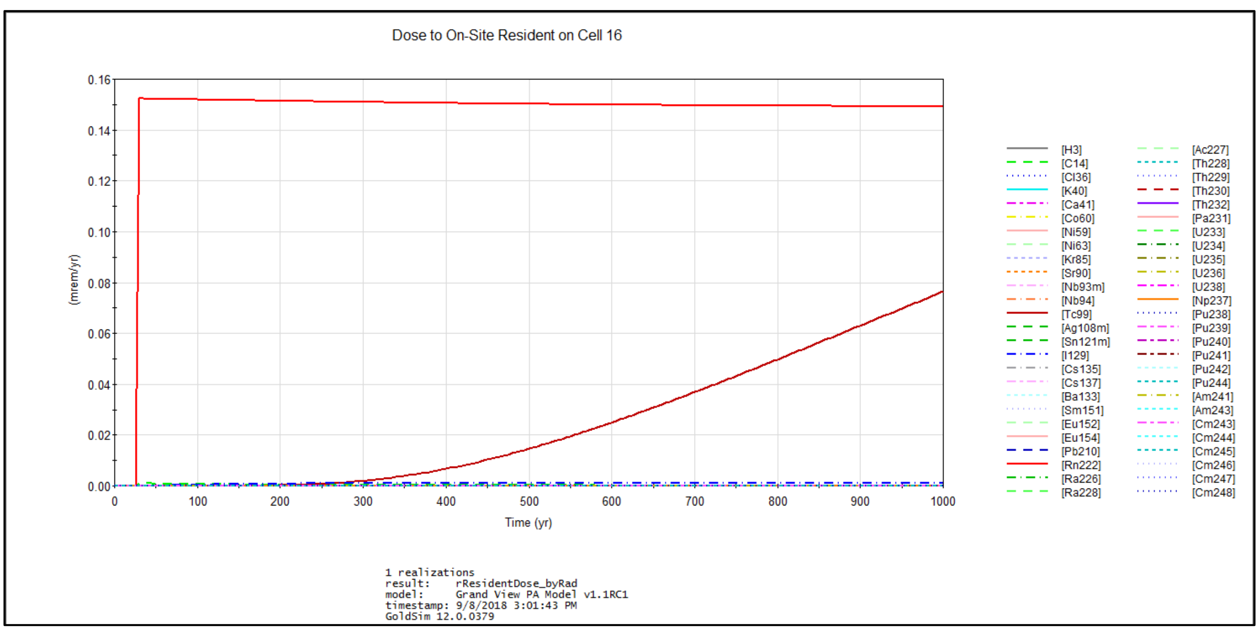

Figure 4. Dose by Rad for On-Site Resident Receptor (Cell 16 only)

Additional discussion, including a comparison of GoldSim SSPA and RESRAD results, is provided in Appendix D. (Neptune 2017)

3.0 Radiological Waste Acceptance Criteria Revisions

This section discusses proposed changes to the Waste Acceptance Criteria (WAC) Tables located in Attachment 2 of the Permit, Waste Acceptance Plan. Detailed changes that USEI is requesting for each Table can be found in the redline markups provided in the permit modification submittal package.

3.1 Proposed Revision to WAC Table C-1: Unimportant Quantities of Source Material Uniformly Dispersed in Soil or Other Media

USEI proposes to delete the footnote that references radioactive contaminated liquids (**), which is found under Table C-3. This change is proposed to be consistent with removing references to radioactive liquids stated elsewhere in this Document (see Section 5.1).

USEI also proposes to move the other two footnotes located under Table C-3 (*, ***). These footnotes refer to Tables C-1 and C-2, and not C-3. USEI feels it will be less confusing if these footnotes are moved directly under the corresponding Tables to which they refer.

3.2 Proposed Revisions to WAC Table C-2: Naturally Occurring Radioactive Material Other Than Uranium and Thorium Uniformly Dispersed in Soil or Other Media

3.2.1 Increased Bulk TENORM Activity Concentrations

USEI proposes to increase the limits of NORM isotopes to 10,000 pCi/g. This would change the concentration limit for total radium from 1,500 pCi/g to 10,000 pCi/g for Radium-226 and/or 228. Concentrations of Lead-210 would also be increased from 1,500 to 10,000 pCi/g. As indicated in Table C-2 below, see Section 3.2.3, the sum of concentrations of all progeny and the parent are changed to be consistent with the NORM increase.

USEI has been able to serve the needs of municipalities and water treatment companies in Idaho and other states who are taking steps to comply with US EPA regulations limiting radium in drinking water under the Safe Drinking Water Act. However, since USEI implemented its last radium WAC modification in 2009, we have learned that these municipalities have an even greater need for safe, secure and cost-effective NORM and TENORM treatment and disposal. Many of these municipalities are small with fiscal challenges that make paying commercial Class A LLRW disposal rates prohibitively expensive. The requested WAC increases in WAC Table C-2 will allow USEI to continue serving these municipalities without causing any significant dose increases to USEI workers, the environment, or members of the public.

Water treatment residuals and filters from the oil and gas industry are another type of waste that would be disposed under this new limit.

The dose assessment performed to evaluate this proposed WAC increase is provided in Section 4.0.

3.2.2 Removal of Industrial Packaging-1 Requirement for Higher-Activity Radium

USEI is also requesting the elimination of the reinforced IP-I containers from WAC Table C-2b. Since 2009, USEI has required shipments containing higher activity radium concentrations (above 500 pCi/g) to have a sealed, clear inner liner. This additional packaging requirement was implemented to help minimize risk from inhalation of radon buildup to USEI workers during visual inspection of these loads.

During the previous 10 years of operations, since the last radium MOD was implemented, USEI has realized that these additional packaging requirements are not required to mitigate worker doses.

USEI proposes to remove this additional packaging requirement for radium loads >500 pCi/g thus standardizing the packaging requirements for all wastes shipped to USEI under WAC Table C.2. Justification for this proposed change includes:

- The number of higher-activity radium shipments to USEI under WAC Table C-2 represents approximately only 5% of USEI's total annual radioactive waste volume.
- The primary hazard that led to the clear plastic liner in 2009 was the potential for radon inhalation that had built up in the headspace of the waste container. Experience over the last nine years working with these waste streams has shown that the radon hazard isn't nearly as high as originally predicted. This is supported by years of radon monitoring data at USEI.
- The radon headspace hazard is primarily an issue for packages that are sealed tight, allowing the radiological decay of the Ra-226 to produce the radon gas without emanation. Bulk waste containers are rarely (if ever) hermetically sealed to the point where radon gas could not escape. A headspace "bubble" of radon that could represent a radiological dose hazard to a USEI worker would require a complete seal that is broken only upon initial inspection. This scenario is not likely for shipments of this type. However, USEI is prepared to implement a procedural change at the Sampling and Inspection Platform and Drum Pad that instructs the technicians to vent all high radium containers from an upwind position prior to performing any intrusive activities with the waste material. An appropriate venting period is expected to be 30-60 seconds, given a slight breeze. Once any headspace is appropriately vented, the radon hazard is mitigated and will not regenerate in the short time frame while the waste is taken to the active face of the landfill and finally disposed.
- USEI is also willing to install additional radon canisters in these workspaces to monitor for elevated radon gas, if it is indeed present.
- Proposed language has been inserted in WAC Table 2 to notate that waste packages containing Ra-226 or Ra-228 >500 pCi/g require controls (i.e. venting).

This change will simplify the packaging requirements and reduce the overall packaging and shipping costs to USEI and our customers while not sacrificing USEI worker safety. Modeled worker dose from this proposed WAC change is detailed in the Dose Assessment provided in Section 4.0. Higher radium waste streams (Table C.2b) will require the venting of containers prior to visual inspections and/or sampling as instructed in the proposed revision to ERMP-01.

3.2.3 Removal of Footnote 1 of WAC Table C-2

Removal of Footnote 1 in WAC Table C-2 is requested to be consistent with clarifications stated in ERMP-04 (see Section 5.4). Disposal practices for Cells 14 and 15 place radium waste streams either below 3.6 meters or 6 meters from the completed surface of the cell, depending on waste concentration. It is currently USEI's practice to place <u>ALL</u> radiological waste under at least 6 meters of cover in Cell 16. Therefore, the reference to "Radium greater than 222 pCi/g" is outdated and is no longer utilized by USEI.

3.2.4 Addition and removal of language in Table C-2a and C-2b

The proposed language to these two parts of the Table are added to help clarify when venting of high concentration radium loads will be performed and when it is not required.

"In bulk form" was removed as to not infer that all radium waste at or below the 500 pCi/g concentration will be in bulk form only.

3.2.5 Addition of second footnote (**) to WAC Table C-2

The addition of this footnote is to give clarification of language added to Table C-2a and C-2b.

3.3 Proposed Revisions to WAC Table C-4b: Materials Specifically Exempted by the NRC or NRC Agreement State

3.3.1 Change to First Footnote (*) of WAC Table C-4b

USEI proposes to increase the sum of all Byproduct Material and Source Material Isotopes to a maximum of 10,000 pCi/g, up from the current limit of 3,000 pCi/g. As demonstrated in Section 4, doses to the member of the public and USEI worker will remain within 100 mRem/yr for the public and well within the USEI ALARA dose limits for the USEI worker.

Also, USEI requests insertion of "SNM may have lower maximum concentration limits due to criticality safety restrictions." Please see discussion of Criticality Safety Considerations in Section 3.5 for more details.

3.3.2 Change to Third Footnote (***) of WAC Table C-4b

USEI proposes to delete reference to "Sum of all isotopes…" as this language is already stated in the first footnote and does not need to be repeated here.

3.4 Proposed Revisions to WAC Table C-4c: Materials Released By Other Agencies

3.4.1 Change to First Footnote (*) of WAC Table C-4c

USEI proposes to increase the sum of all Byproduct Material and Source Material Isotopes to a maximum of 10,000 pCi/g, up from the current limit of 3,000 pCi/g. As demonstrated in Section 4, doses to the member of the public and USEI worker will remain within 100 mRem/yr for the public and well within the USEI ALARA dose limits for the USEI worker.

3.4.2 Change to Second Footnote (**) of WAC Table C-4c

USEI requests insertion of "SNM may have lower maximum concentration limit due to criticality safety restrictions." Please see discussion in Section 3.5 for details.

3.5 Special Nuclear Material Criticality Safety Considerations

Special Nuclear Material requires special consideration due to the potential for criticality of the fissile radioisotope U-235 at mass enrichments above that of natural uranium. Uranium found in the earth has a U-235 mass abundance of 0.71%. In order for uranium to be fissile in light water nuclear reactors in the United States, the abundance of U-235 (within the total mass of all uranium) must be "enriched" above this 0.71% value. Light water reactors in the US typically run uranium fuel with U-235 enrichments between 3-5%, by mass.

USEI has been able to receive SNM with enriched uranium as well as plutonium for disposal since 2009, provided the sum of all uranium isotopes (U-234, U-235, and U-238) is less than or equal to 3,000 pCi/g. What makes uranium unique is that the isotope activity concentrations change as mass enrichment of the U-235 changes. This is due to very different specific activity constants for each of the three isotopes. This is shown in Table 5.

Table 5. Specific Activity Constants for Uranium Isotopes

Isotope	Specific Activity Constant (Curies per Gram of Isotope)
U-234	6.23E-03
U-235	2.16E-06
U-238	3.36E-07

The different specific activity constants for each isotope means that as the mass abundance of each isotope changes within the uranium mixture, the total activity of the mixture also changes. The effect of U-235 enrichment on the total uranium mix activity fractions are shown in Table 6.

Table 6. Effect of U-235 Enrichment on Uranium Isotope Activity Concentrations

U-235 Mass Enrichment	U-234 Activity (pCi/g)	U-235 Activity (pCi/g)	U-238 Activity (pCi/g)	Total Uranium Activity (pCi/g)
0.71%	1,440	68.6	1,490	3,000
2%	2,050	111	843	3,000
3%	2,250	124	624	3,000
5%	2,460	136	401	3,000

As Table 6 shows, even though the total uranium activity remains constant at 3,000 pCi/g, the individual isotopes activity concentrations can vary significantly with U-235 enrichment. These varying activity concentrations are important to USEI since the current WAC Tables C.4b and C.4c limit the total SNM activity to 3,000 pCi/g.

A further complicating factor is criticality safety, which is a determination of how much enriched uranium USEI may have in its landfills (in terms of fissile density [units of grams U-235 per liter of waste matrix]). During evaluation of the Alternate Disposal Authorization submittals for the Westinghouse Hematite Site, the U.S. NRC placed a fissile density limit of 0.1 g/L of U-235 on USEI. This value is far below a known threshold for actual criticality but was chosen as appropriate for USEI since it is a non-licensed RCRA hazardous waste facility. The fissile density limit is related to USEI's WAC concentration limit since nuclide concentrations (and total uranium mixture concentrations) can be calculated for various fissile density limits. For example, Table 7 is a sensitivity analysis of Total Uranium Concentration (in pCi/g) versus U-235 enrichment for a steady fissile density limit of 0.1 g/L. This analysis is informative as it allows USEI to determine the maximum total uranium mixture activity concentration that could be allowed while still adhering to the fissile density limit imposed by the U.S. NRC.

Table 7. Sensitivity Analysis of U-235 enrichment vs. Total Uranium Mixture Concentration at 0.1 g/L.

	Total Uranium Mixture Concentration (pCi/g)									
U-235 Enrich%	**500**	**1000**	**1500**	**2000**	**2500**	**3000**	**3500**	**4000**	**4500[2]**	**5000**
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.71	0.005	0.011	0.016	0.021	0.026	0.032	0.037	0.042	0.048	0.053
1	0.006	0.013	0.019	0.026	0.032	0.038	0.045	0.051	0.058	0.064
1.5	0.008	0.015	0.023	0.031	0.038	0.046	0.054	0.061	0.069	0.077
2	0.009	0.017	0.026	0.034	0.043	0.051	0.060	0.068	0.077	0.085
2.5	0.009	0.018	0.027	0.037	0.046	0.055	0.064	0.073	0.082	0.091
3	0.010	0.019	0.029	0.038	0.048	0.057	0.067	0.077	0.086	0.096
4	0.010	0.020	0.030	0.041	0.051	0.061	0.071	0.081	0.091	0.102[1]
5	0.011	0.021	0.032	0.042	0.053	0.063	0.074	0.084	0.095	0.105
6	0.011	0.021	0.032	0.043	0.054	0.064	0.075	0.086	0.097	0.107
7	0.011	0.022	0.033	0.044	0.054	0.065	0.076	0.087	0.098	0.109
8	0.011	0.022	0.033	0.044	0.055	0.066	0.077	0.088	0.099	0.110
9	0.011	0.022	0.033	0.044	0.055	0.066	0.077	0.088	0.099	0.110
10	0.011	0.022	0.033	0.044	0.055	0.066	0.077	0.088	0.099	0.110

Notes:

1. Red shaded cells indicate a combination of U-235 enrichment and Total Uranium Mixture Concentration that yield a fissile density >0.1 g/L (NOT ALLOWED).
2. 4,500 pCi/g is the highest Total Uranium concentration that could be received at USEI (up to 10% enrichment) and stay below the criticality density limit of 0.1g/L.

The sensitivity analysis in Table 7 illustrates that USEI may increase its acceptable SNM values in WAC Tables C-4b and C-4c to 4,500 pCi/g for up to 10% enriched uranium and up to 5,000 pCi/g for up to 3% enriched uranium. Enriched uranium is not limiting from a dose perspective in the GoldSim model, so all practical constraints on the WAC values are being driven by potential criticality concerns only. Given these analyses, USEI respectfully requests an increase to the SNM WAC limit in Tables C-4b and C-4c to 4,500 pCi/g (up to 10% enrichment).

4.0 Radiological Dose Assessment

The potential impact of the increased radiological WAC to USEI workers and the surrounding environment has been evaluated.

4.1 Dose Assessment Assumptions and Inputs

4.1.1 Volume of Higher Activity Radioactive Waste

The target business lines expected to be served by the increased WAC include TENORM from oil and gas exploration and development and TENORM from water treatment system residuals. In both cases, the primary radionuclide of concern is radium (Ra-226 and Ra-228). USEI already serves these business lines, but not to the extent possible, given the current WAC limits in Table C-2.

To determine the potential annual volume receipts of these types of wastes at an increased level, historical waste volumes of similar types at USEI were investigated. Table 8 provides a 5-year record of radiological waste volumes at USEI as reported to IDEQ in Exempt Radioactive Materials Reports. The total number of radium loads with concentrations greater than 500 pCi/g was compared to total Radiological waste receipts for the past five years. This historical data showed that about 5% of all radiological loads consisted of radium material greater than 500 pCi/g. To be conservative and to account for potential growth in this area of waste, a ratio of 7% was used for performing the pro-forma dose modeling.

Table 8. USEI Historical Radiological Waste Receipts

Radioactive Waste Type	2013	2014	2015	2016	2017
FUSRAP	53,942	90,639	111,685	84,695	60,042
NORM	83,752	47,323	57,034	37,858	19,801
Exempt	70,042	47,074	75,859	16,111	8,075
Total Annual Rad Waste (tons)	207,737	185,038	244,579	138,665	87,919
5-yr Average All Rad (tons)	172,788				
5-yr Avg High-Activity Rad (5%, tons)	8,640				
Assumed High-Activity Rad (7%, tons)	***12,095***				

4.1.2 Dose Modeling Assumptions

Occupational doses to USEI workers were modeled using the same historical methods used for other dose assessments. External dose rates were modeled using the MicroShield computer code (ver. 10). The dose rates were calculated using unit concentrations at 1 pCi/g, since results are scalable to any radionuclide concentration once the unit dose rates are known. The calculated dose rates were then entered into a "time-motion study" spreadsheet to estimate total annual exposure to each worker assigned to a critical job function. The equation used for the time-motion study is shown below.

$$Dose = \frac{(Waste\ Contact\ Time)(External\ Exposure\ Rate)(Total\ number\ of\ Repetitions)}{Total\ Number\ of\ Workers}$$

The key inputs and assumptions to the time-motion study are provided below:

- Of the radiological waste received at USEI over the past five years 40% was received over the road direct to Site B via truck whereas 60% was received through the RTF. In addition, it was assumed that the direct waste volume consisted of 95% bulk loads and 5% drum loads.
- Waste contact times were determined by a combination of measuring the time the actual job took to perform and operator knowledge.
- Total number of repetitions is based on the total volume received divided by shipment and time information explained in the two previous assumptions above.
- Number of workers per function is based on current practices. For the Back-End Dray Truck Drivers, the number of drivers can vary from as few as 4 to as many as 18, based on need. For this dose assessment 12 drivers were used.
- TENORM: Ra-226, in equilibrium with its progeny and Pb-210 (alone) were used as the nuclides of interest for this dose assessment as they are the primary contaminants in oil and gas or water treatment TENORM waste streams. Dose calculations for Ra-226 and Pb-210 were run independently since Pb-210 is part of the Ra-226 decay chain.
- Byproduct Material: Several high-energy gamma emitting nuclides were chosen to simulate shipments containing byproduct material. Cesium-137 (Cs-137), Cobalt-60 (Co-60), and Europium-152 (Eu-152) were chosen for this purpose as they typically provide the most dose from shipments from nuclear power plants or similar generators that contain byproduct material.

- Source Material: Waste containing Uranium and Thorium in varying concentrations and configurations were modeled to evaluate doses from shipments containing Source Material. Configurations were modeled that emulate customers USEI already serves such as the mining industry, the US Army Corps of Engineers FUSRAP program, and rare-earth processors. To achieve this, Uranium was modeled as both "natural," where the parent U-238 and its decay progeny are in equilibrium; and as "refined," where chemical processes have been used to disrupt the decay chain. Thorium (Th-232) was modeled in equilibrium due to the relatively short half-lives of its decay progeny.
- Waste Stream Average concentrations of 500 pCi/g, 2,000 pCi/g, and 10,000 pCi/g were all modeled to determine potential worker dose impact. Even though USEI is requesting a maximum WAC value of 10,000 pCi/g on a per-shipment basis, the average concentrations that are expected over a year are expected to be much lower. This has been shown to be true for both TENORM (WAC Table 2) and Byproduct/Source Material (WAC Tables C.4b/c) at USEI since the last WAC increases in 2009. Actual received concentrations have only averaged 100-200 pCi/g for TENORM and 30-50 pCi/g for byproduct and source material shipments over this time.

4.1.3 Dose Modeling Methods

All pro forma occupational doses performed in this Safety Assessment were done using USE's Site-Specific Dose Assessment (SSDA) tool. The SSDA was developed to quickly perform dose assessments associated with waste handling transportation and disposal from customer sites to the USEI facility. The SSDA tool was primarily developed to support obtaining licensing exemptions for purposes of alternate disposal of wastes at USEI in accordance with 10 CFR 20.2002. However, it may be used for any project or application where doses associated with radioactive waste at USEI are involved. The SSDA (Rev 3) has been vetted and approved for use by the US NRC. Details of the construction, logic, and use instructions for the SSDA may be found in the Technical Basis Document (USE 2017).

4.2 Dose Assessment Results

4.2.1 Occupational Workers at USEI

Occupational worker doses have been calculated for all job functions at USEI that may come into contact with the levels of radioactive material discussed in this Modification. The dose calculations correspond to USEI's individual WAC Tables, where changes are being requested. All calculations use the assumptions outlined in Section 4.1. The dose calculations performed for each WAC section were done independently so that the same assumptions and shipment parameters could be used for each. Therefore, the dose results provided in Section 4.2.1 are not intended to be summed for the same listed job functions.

4.2.1.1 WAC Table C.2 – NORM/TENORM

The results of the Dose Assessment for WAC Table C.2 – NORM/TENORM are provided in Table 9. Separate calculations were performed for Ra-226 and Pb-210 as described in Section 4.1.

The maximally exposed individual (MEI) at USEI for the Ra-226 scenario is the Back-End Dray Truck Driver from the RTF to the USEI landfill (76.4 mRem/yr), followed by the USEI Landfill Cell Operator (65.7 mRem/yr) and RTF Excavator Operator (62.1 mRem/yr). This scenario confirmed that MEI worker doses could be held less than 100 mRem/yr even assuming the worst-case scenario that 100% of the elevated radwaste volume received is at the proposed WAC maximum of 10,000 pCi/g.

These results are considerably less than USEI's administrative dose limit of 400 mRem/yr and also within the 100 mRem/yr member of the public dose limit in 10 CFR 20.1003. As stated previously, USEI's experience with NORM/TENORM waste receipts indicates that the average actual concentrations will be considerably less than those modeled. For example, if the elevated waste receipts instead average ~500 pCi/g Ra-226, Table 9 predicts an MEI dose of only 5 mRem/yr. Virtually no external exposure is expected from elevated Pb-210 shipments since there is very little gamma radiation emitted.

Table 9. Results of TENORM Dose Assessment

Function	Minimum Number of Workers	Waste Contact Time (hr)	Ra-226 External Exposure Rate: (mR/hr @ 1 pCi/g)	Pb-210 External Exposure Rate: (mR/hr @ 1 pCi/g)	Distance (m)	Total No. of Repetitions	Job Function Dose Estimate at Three Average Ra-226[1] Activity Concentrations			Pb-210[1] Dose Estimate
							@500 pCi/g[2] (mRem)	@2000 pCi/g[3] (mRem)	@10,000 pCi/g (mRem)	@10,000 pCi/g (mRem)
Railcar Surveyors	4	0.08	5.61E-04	8.00E-13	1.0	73	0.4	1.6	8.2	0.00
Bulk/IMC Truck Surveyors	4	0.05	8.83E-04	6.86E-08	1.0	355	2.0	7.8	39.2	0.00
Container Pad Operators	8	0.13	7.81E-05	3.23E-14	1.0	1066	0.7	2.7	13.5	0.00
RTF Excavator Operator	2	0.50	3.40E-04	7.32E-08	2.0	73	3.1	12.4	62.1	0.01
Gondola Railcar Cleanout	4	0.16	1.19E-04	1.29E-06	0.3	73	0.2	0.7	3.5	0.04
Back-End Dray Truck Drivers	12	0.75	5.74E-04	8.63E-08	0.6	213	3.8	15.3	76.4	0.01
Treatment Workers	6	0.75	1.98E-04	4.30E-08	2.0	61	0.8	3.0	15.1	0.00
Treatment Plant Truck Driver	2	0.16	5.20E-05	8.58E-09	0.6	151	0.3	1.3	6.3	0.00
Container Pad Truck Driver	2	0.16	7.81E-05	3.23E-14	2.0	27	0.1	0.3	1.7	0.00
Landfill Cell Operators	2	0.25	2.18E-04	7.00E-18	1.0	241	3.3	13.1	65.7	0.00

Notes:

1. Ra-226 in complete equilibrium was modeled as the limiting case nuclide for the dose assessment. USEI's WAC is actually defined as "Ra-226+Ra-228" but the combination scenarios do not warrant special consideration. Pb-210 does not contribute significant dose.
2. 500 pCi/g is the current USEI WAC limit for "bulk TENORM waste" in Table C-2.
3. USEI's current limit for TENORM in sealed IP-1 packages is 1,500 pCi/g. Dose results for 2,000 pCi/g are shown here for illustration purposes.

4.2.1.2 WAC Table C.4b/c - Byproduct Material

The results of the Dose Assessment for various Byproduct Material (BPM) nuclides are presented in Table 10, Table 11, and Table 12. Separate calculations were performed for Cs-137, Co-60, and Eu-152, respectively as described in Section 4.1.

Like the results for Ra-226, the MEI's at USEI continue to be the USEI Landfill Cell Operator, the RTF Excavator Operator, and Back-End Dray Truck Driver from the RTF to the USEI landfill. Nearly all results were found to be less than the 100 mRem/yr member of the public dose limit in 10 CFR 20.1003. The only exceptions were for Co-60 at the maximum concentration of 10,000 pCi/g, where dose estimates came in between 91-113 mRem/yr for the MEI job functions. As previously discussed, modeling at the max concentrations was done as a conservative measure to assess potential maximum impact, not as a case study of what USEI could actually expect. Regardless, the predicted dose levels were still found to be less than USEI's administrative dose limit of 400 mRem/yr.

Table 10. Results of BPM Dose Assessment – Cs-137

Function	Minimum Number of Workers	Waste Contact Time (hr)	Cs-137 External Exposure Rate: (mR/hr @ 10,000 pCi/g	Cs-137 External Exposure Rate: (mR/hr @ 1 pCi/g)	Distance (m)	Total No. of Repetitions	Job Function Dose Estimate at Three Average Cs-137 Activity Concentrations		
							@ 500 pCi/g (mRem)	@ 2000 pCi/g (mRem)	@ 10,000 pCi/g (mRem)
Railcar Surveyors	4	0.08	1.78E+00	1.78E-04	1.0	73	0.1	0.5	2.6
Bulk/IMC Truck Surveyors	4	0.05	1.51E+00	1.51E-04	1.0	355	0.3	1.3	6.7
Container Pad Operators	8	0.13	2.71E-01	2.71E-05	1.0	1066	0.2	0.9	4.7
RTF Excavator Operator	2	0.50	1.09E+00	1.09E-04	2.0	73	1.0	4.0	19.9
Gondola Railcar Cleanout	4	0.16	0.00E+00	0.00E+00	0.3	73	0.0	0.0	0.0
Back-End Dray Truck Drivers	12	0.75	4.24E-02	4.24E-06	0.6	213	0.0	0.1	0.6
Treatment Workers	6	0.75	6.38E-01	6.38E-05	2.0	61	0.2	1.0	4.9
Treatment Plant Truck Driver	2	0.16	1.66E-01	1.66E-05	0.6	151	0.1	0.4	2.0
Container Pad Truck Driver	2	0.16	2.71E-01	2.71E-05	2.0	27	0.0	0.1	0.6
Landfill Cell Operators	2	0.25	6.63E-01	6.63E-05	1.0	241	1.0	4.0	20.0

Table 11. Results of BPM Dose Assessment – Co-60

Function	Minimum Number of Workers	Waste Contact Time (hr)	Co-60 External Exposure Rate: (mR/hr@10,000 pCi/g	Co-60 External Exposure Rate: (mR/hr @ 1 pCi/g)	Distance (m)	Total No. of Repetitions	Job Function Dose Estimate at Three Average Co-60 Activity Concentrations		
							@ 500 pCi/g (mRem)	@ 2000 pCi/g (mRem)	@ 10,000 pCi/g (mRem)
Railcar Surveyors	4	0.08	8.49E+00	8.49E-04	1.0	73	0.62	2.5	12.4
Bulk/IMC Truck Surveyors	4	0.05	6.83E+00	6.83E-04	1.0	355	1.52	6.1	30.3
Container Pad Operators	8	0.13	1.15E+00	1.15E-04	1.0	1066	1.00	4.0	19.9
RTF Excavator Operator	2	0.50	4.99E+00	4.99E-04	2.0	73	4.55	18.2	91.1
Gondola Railcar Cleanout	4	0.16	1.69E+00	1.69E-04	0.3	73	0.25	0.99	4.93
Back-End Dray Truck Drivers	12	0.75	8.52E+00	8.52E-04	0.6	213	5.67	22.7	113.4
Treatment Workers	6	0.75	2.96E+00	2.96E-04	2.0	61	1.13	4.51	22.6
Treatment Plant Truck Driver	2	0.16	7.64E-01	7.64E-05	0.6	151	0.46	1.85	9.23
Container Pad Truck Driver	2	0.16	2.71E-01	2.71E-05	2.0	27	0.12	0.50	2.48
Landfill Cell Operators	2	0.25	6.63E-01	6.63E-05	1.0	241	4.97	19.9	99.4

Table 12. Results of BPM Dose Assessment – Eu-152

Function	Minimum Number of Workers	Waste Contact Time (hr)	Eu-152 External Exposure Rate: (mR/hr@10,000 pCi/g	Eu-152 External Exposure Rate: (mR/hr @ 1 pCi/g)	Distance (m)	Total No. of Repetitions	Job Function Dose Estimate at Three Average Eu-152 Activity Concentrations		
							@ 500 pCi/g (mRem)	@ 2000 pCi/g (mRem)	@ 10,000 pCi/g (mRem)
Railcar Surveyors	4	0.08	3.49E+00	3.49E-04	1.0	73	0.25	1.02	5.10
Bulk/IMC Truck Surveyors	4	0.05	2.90E+00	2.90E-04	1.0	355	0.64	2.57	12.9
Container Pad Operators	8	0.13	4.92E-01	4.92E-05	1.0	1066	0.43	1.70	8.52
RTF Excavator Operator	2	0.50	2.12E+00	2.12E-04	2.0	73	1.93	7.74	38.7
Gondola Railcar Cleanout	4	0.16	7.94E-01	7.94E-05	0.3	73	0.12	0.46	2.32
Back-End Dray Truck Drivers	12	0.75	3.63E+00	3.63E-04	0.6	213	2.42	9.66	48.3
Treatment Workers	6	0.75	1.25E+00	1.25E-04	2.0	61	0.48	1.91	9.53
Treatment Plant Truck Driver	2	0.16	3.23E-01	3.23E-05	0.6	151	0.20	0.78	3.90
Container Pad Truck Driver	2	0.16	4.92E-01	4.92E-05	2.0	27	0.05	0.21	1.06
Landfill Cell Operators	2	0.25	1.33E+00	1.33E-04	1.0	241	2.00	8.01	40.1

4.2.1.3 WAC Table C.4b/c – Source Material

The results of the Dose Assessment for various Source Material nuclides are presented in Table 13, Table 14, and Table 15. Separate calculations were performed for Natural Uranium (in equilibrium), Refined Uranium (which has had equilibrium disrupted due to chemical separation), and Natural Thorium in Equilibrium. These configurations were chosen as they best represent waste streams that USEI already receives.

The MEI's at USEI for these waste types continue to be the USEI Landfill Cell Operator, the RTF Excavator Operator, and Back-End Dray Truck Driver from the RTF to the USEI landfill. Nearly all results were found to be less than the 100 mRem/yr member of the public dose limit in 10 CFR 20.1003. The only exceptions were for Natural Uranium and Natural Thorium at the maximum concentration of 10,000 pCi/g, where dose estimates came in between 130-215 mRem/yr for the MEI job functions. As previously discussed, modeling at the max concentrations was done as a conservative measure to assess potential maximum impact, not as a case study of what USEI could actually receive in a given year. Regardless, the predicted dose levels were still found to be less than USEI's administrative dose limit of 400 mRem/yr.

Table 13. Results of Source Material Dose Assessment – Natural Uranium

Function	Minimum Number of Workers	Waste Contact Time (hr)	Nat U External Exposure Rate: (mR/hr@10,000 pCi/g	Nat U External Exposure Rate: (mR/hr @ 1 pCi/g)	Distance (m)	Total No. of Repetitions	Job Function Dose Estimate at Three Average Nat U Activity Concentrations		
							@ 500 pCi/g (mRem)	@ 2000 pCi/g (mRem)	@ 10,000 pCi/g (mRem)
Railcar Surveyors	4	0.08	1.18E+01	1.18E-03	1.0	73	0.86	3.45	17.2
Bulk/IMC Truck Surveyors	4	0.05	9.86E+00	9.86E-04	1.0	355	2.19	8.75	43.8
Container Pad Operators	8	0.13	8.16E-01	8.16E-05	1.0	1066	0.71	2.83	14.1
RTF Excavator Operator	2	0.50	7.17E+00	7.17E-04	2.0	73	6.54	26.2	130.9
Gondola Railcar Cleanout	4	0.16	2.67E+00	2.67E-04	0.3	73	0.39	1.56	7.80
Back-End Dray Truck Drivers	12	0.75	1.23E+01	1.23E-03	0.6	213	8.19	32.7	163.7
Treatment Workers	6	0.75	4.23E+00	4.23E-04	2.0	61	1.61	6.45	32.3
Treatment Plant Truck Driver	2	0.16	1.09E+00	1.09E-04	0.6	151	0.66	2.63	13.2
Container Pad Truck Driver	2	0.16	8.16E-01	8.16E-05	2.0	27	0.09	0.35	1.76
Landfill Cell Operators	2	0.25	4.49E+00	4.49E-04	1.0	241	6.76	27.1	135.3

Table 14. Results of Source Material Dose Assessment – Refined Uranium

Function	Minimum Number of Workers	Waste Contact Time (hr)	Refined U External Exposure Rate: (mR/hr@10,000 pCi/g	Refined U External Exposure Rate: (mR/hr @ 1 pCi/g)	Distance (m)	Total No. of Repetitions	Job Function Dose Estimate at Three Average Refined U Activity Concentrations		
							@ 500 pCi/g (mRem)	@ 2000 pCi/g (mRem)	@ 10,000 pCi/g (mRem)
Railcar Surveyors	4	0.08	3.43E-02	3.43E-06	1.0	73	0.00	0.01	0.05
Bulk/IMC Truck Surveyors	4	0.05	3.58E-02	3.58E-06	1.0	355	0.01	0.03	0.16
Container Pad Operators	8	0.13	5.25E-03	5.25E-07	1.0	1066	0.00	0.02	0.09
RTF Excavator Operator	2	0.50	3.94E-02	3.94E-06	2.0	73	0.04	0.14	0.72
Gondola Railcar Cleanout	4	0.16	2.27E-02	2.27E-06	0.3	73	0.00	0.01	0.07
Back-End Dray Truck Drivers	12	0.75	4.55E-02	4.55E-06	0.6	213	0.03	0.12	0.61
Treatment Workers	6	0.75	1.38E-02	1.38E-06	2.0	61	0.01	0.02	0.11
Treatment Plant Truck Driver	2	0.16	3.87E-03	3.87E-07	0.6	151	0.00	0.01	0.05
Container Pad Truck Driver	2	0.16	5.25E-03	5.25E-07	2.0	27	0.00	0.00	0.01
Landfill Cell Operators	2	0.25	3.51E-03	3.51E-07	1.0	241	0.01	0.02	0.11

Table 15. Results of Source Material Dose Assessment – Thorium

Function	Minimum Number of Workers	Waste Contact Time (hr)	Thorium External Exposure Rate: (mR/hr@10,000 pCi/g	Thorium External Exposure Rate: (mR/hr @ 1 pCi/g)	Distance (m)	Total No. of Repetitions	Job Function Dose Estimate at Three Average Thorium Activity Concentrations		
							@ 500 pCi/g (mRem)	@ 2000 pCi/g (mRem)	@ 10,000 pCi/g (mRem)
Railcar Surveyors	4	0.08	1.64E+01	1.64E-03	1.0	73	1.20	4.79	23.9
Bulk/IMC Truck Surveyors	4	0.05	9.85E+00	9.85E-04	1.0	355	2.19	8.74	43.7
Container Pad Operators	8	0.13	2.09E+00	2.09E-04	1.0	1066	1.81	7.24	36.2
RTF Excavator Operator	2	0.50	9.61E+00	9.61E-04	2.0	73	8.77	35.1	175.4
Gondola Railcar Cleanout	4	0.16	3.05E+00	3.05E-04	0.3	73	0.45	1.78	8.91
Back-End Dray Truck Drivers	12	0.75	1.62E+01	1.62E-03	0.6	213	10.8	43.1	215.7
Treatment Workers	6	0.75	5.73E+00	5.73E-04	2.0	61	2.18	8.74	43.7
Treatment Plant Truck Driver	2	0.16	1.48E+00	1.48E-04	0.6	151	0.89	3.58	17.9
Container Pad Truck Driver	2	0.16	2.09E+00	2.09E-04	2.0	27	0.23	0.90	4.51
Landfill Cell Operators	2	0.25	6.46E+00	6.46E-04	1.0	241	9.73	38.9	194.6

4.2.2 Supporting Radiation Safety Experience

All USEI workers that actively handle and dispose of radioactive waste are assigned dosimetry to track their exposure. Historical dosimetry data for USEI has shown that workers performing job functions that receive, treat and dispose of several hundred thousand tons of low-activity radioactive materials every year, including 8,000-10,000 tons of higher activity shipments do not receive more than 20-30 mRem/yr of radiation exposure. This includes higher-activity shipments of TENORM up to 1,500 pCi/g and accelerator-produced and other exempt radiological materials with external dose rates up to 10 mRem/hr since 2009. In fact, many workers do not receive any reportable dose above the minimum detectable quantity of our dosimetry processing laboratory.

Due to the nature of the time-motion studies used to calculate these pro-forma doses, the dose assessment results in Table 9 through Table 15 are conservatively estimated. This is due to the use of multiple, compounded conservative assumptions built into the modeling. Examples of the conservative assumptions include the high average concentrations of received waste; that the worker stays in the same fixed position for the entirety of the exposure period; and that each fraction of a milliRem is accounted for during the entire year, whereas dosimetry processors typically round down fractions that are less than 1 mRem.

Based on historical performance of the radiation protection program at USEI, we expect the actual measured exposures to be much lower than what is being projected in this Safety Assessment.

4.3 Environmental and Post-Closure Pathways

USEI has been performing environmental monitoring for many years. This program consists of monitoring penetrating radiation at the fence line of the facility, Radon monitoring, ground water, soil, and air monitoring. Annual reports are developed to present the previous year's monitoring results. The annual report also includes a calculated dose to members of the public based on that years monitoring data. The 2017 environmental report had a calculated dose to the public of 6.7 mRem/yr. Reports from previous years give very similar doses, all of which are well below the public dose limit of 100 mRem/yr.

It is very unlikely that there will be a significant increase in the calculated public dose and monitoring data due to the increased WAC limits. Again, this material will represent a very small percentage of waste received at USEI, and ambient radiation levels will not increase by any significant amounts from this waste. USEI currently accepts certain waste streams with dose rates up to 10 mR/hr, which is on scale with expected dose rates of a radium load at 10,000 pCi/g. Public dose associated with increased radium levels will remain well within the required limits of 100 mRem/yr.

5.0 ERMP Procedure Revisions

Detailed changes that USEI is requesting for each ERMP can be found in the redline markups provided in the permit modification submittal package. Below is a general discussion of the requested changes.

5.1 ERMP-01 *Receipt of Material*

ERMP-01 provides instructions and action levels for the receipt, inspection, and survey of radiological material received at USEI's rail transfer facility and Site B.

Instructions throughout the procedure were repetitive and redundant, such as instructions for Class 7 contamination surveys. These redundancies were condensed into one section. Each section format was rearranged throughout the procedure. The intent of these changes was to improve the flow of the procedure for more efficient referencing.

DOT contamination levels were updated to accurately reflect 49 CFR 173.443 from 6,600 dpm /300 cm^2 to 7,200 dpm /300 cm^2. This corresponds to 24 dpm/cm^2.

WAC increases for NORM are proposed to increase from 1,500 to 10,000 pCi/g. With this proposal, Table C-2a gamma action levels will remain unchanged. All loads with radium >500 pCi/g (Table C-2b) will continue to require waste stream specific action levels. All Table C-2b radium loads will be vented for at least one minute prior to inspection and fingerprinting while personnel remain upwind.

References to liquid waste were removed. Historically, USEI has not been permitted to receive radioactive liquids (liquids >40 µR/h). USEI has been allowed to receive and solidify liquids with dose rates <40 µR/h in order to process wash water collections as well as various projects. USEI requests the ability to receive and process radioactive liquids under the same WAC requirements of solid radiological media. Liquid radioactive waste will be required to meet WAC limits prior to solidification, with grams being equivalent to milliliters (e.g., pCi/g = pCi/ml).

5.2 ERMP-02 *Decontamination and Return to Service of Empty Containers*

ERMP-02 provides instructions to ensure that all containers that are returned to service will meet DOT standards.

In Section 1.1, the dpm in footnote * was updated to reflect the contamination definition found in 49 CFR 173.443, Table 9. For example, 24 dpm/cm^2 equals 7,200 dpm/300 cm^2.

Minor changes were made to Figure 2-1, *Empty Container Decontamination / Return to Service Form.* The Returned to Service removable contamination level was updated from 6,600 dpm/300 cm^2 to 7,200 dpm/300 cm^2 in accordance with 49 CFR 173.443, Table 9. Other changes include minor formatting and improvements to the survey sampling location diagram.

Instructions for performance and reliability testing of survey instruments has been removed. These instructions, including Figures 2-2 and 2-3, were moved to ERMP-06 *Selection, Care, and Use of Portable Instrumentation*.

Instructions to wipe empty containers were changed to include internal and external surfaces to be more consistent with 49 CFR 173.443. Previous procedures only required taking wipes of the internal surfaces.

5.3 ERMP-03 *Environmental Monitoring Program Overview*

ERMP-03 lists monitoring locations, frequencies, and investigation levels for all mediums included in the environmental monitoring program.

The intent of ERMP-03 is to provide guidance, including investigation levels, for non-occupational environmental monitoring. Occupational investigation levels for radon were removed from ERMP-03. An occupational monitoring guide will be established as part of the Health and Safety Manual and ALARA program. Occupational monitoring will include investigation levels for radon, ambient gamma, and air particulates.

Table 3-2 contains a list of groundwater wells designated for radiological sampling. The table was edited to remove the duplicate L-32 and well U-1 that was closed in 2012.

5.4 ERMP-04 *Landfill Operations*

ERMP-04 describes landfill operations, including waste placement, with regards to burial depths required to mitigate radon emanation.

References to RESRAD modeling have been changed to GoldSim. Burial depths will remain unchanged. GoldSim modeling demonstrates that 3.6 and 6 meter burial depths provide a thick enough diffusion barrier to meet the limits established in IDAPA 58.01.10.020.03(a)(ii).

5.5 ERMP-05 *Waste Acceptance Criteria Evaluation*

ERMP-05 provides guidance for the exceedance of action levels including removable contamination.

The section referring to the exceedance of action levels for bulk and non-bulk liquids was removed. Action levels for liquids will be the same as solids with grams and milliliters being interchangeable.

Previous permit requirements restricted the receipt of radioactive liquids, which have been defined as any liquid possessing a dose rate of greater than 40 µR/h. See proposed changes to ERMP-01 (see Section 5.1).

5.6 ERMP-06 *Selection, care, and Use of Portable Instrumentation*

ERMP-06 provides instructions regarding survey instruments that are used at USEI.

A section was moved from ERMP-02 to ERMP-06 that discusses instrument reliability and performance testing. Figures 2-2 and 2-3 were also moved from ERMP-02 to ERMP-06 as Figures 6-1 and 6-2. No other changes were made.

6.0 References

DBSA, 2010 Final Cover Design for Cells 14 and 15, Permit Modification for Alternative Evapotranspiration Final Cover, US Ecology Idaho, Volume 1: Report, Figures, Tables, Appendices A—D, prepared for US Ecology Idaho Inc., Daniel B. Stephens & Associates Inc., Albuquerque NM, October 2010

Neptune, 2016 US Ecology Idaho Grand View Conceptual Site Model. NAC-0065_R1. Neptune and Company, Inc. Lakewood, CO. October 2016.

Neptune, 2017 Grand View Performance Assessment Groundwater Pathway: Analysis of Prior Research & Models. NAC-0077_R0. Neptune and Company, Inc. Lakewood, CO. January 2017.

Neptune, 2017 NAC-0096_R1. Neptune and Company, Inc. Lakewood, CO. October 2017.

Neptune, 2018 Modeling Input Parameters for the Grand View PA Model v1.1. NAC-0078_R0. Neptune and Company, Inc. Lakewood, CO. September 2018.

Neptune, 2018 NAC-0096_R2. Neptune and Company, Inc. Lakewood, CO. September 2018.

USEI, 2009 HWMA Treatment, Storage, and Disposal Permit for the U.S. Ecology Idaho Inc. Site B Facility EPA ID No. IDD073114654. July 2009.

USE, 2017 Technical Basis Document - Site-Specific Dose Assessment Methodology for US Ecology Idaho In Support of Alternate Waste Disposal Procedures in Accordance With 10 CFR 20.2002, Rev. 3. US Ecology, Inc. February 2017.

APPENDIX A

US Ecology Idaho Grand View Conceptual Site Model.

NAC-0065_R1.

(99 pages)

APPENDIX B

Grand View Performance Assessment Groundwater Pathway: Analysis of Prior Research & Models.

NAC-0077_R0.

(26 pages)

APPENDIX C

Modeling Input Parameters for the Grand View PA Model v1.1

NAC-0078_R2.

(44 pages)

APPENDIX D

Grand View GoldSim PA Model v1.0: Results and Comparison to Grand View RESRAD PA Model.

NAC-0093_R1.

(45 pages)

APPENDIX E

Sensitivity Analysis for the Grand View PA Model v1.1.

NAC-0096_R2.

(36 pages)

APPENDIX F

Letter to J Weismann from J Tappert. "US ECOLOGY, INC. – TECHNICAL EVALUATION REPORT OF REVISION THREE OF US ECOLOGY'S SITE-SPECIFIC DOSE ASSESSMENT METHODOLOGY." US Nuclear Regulatory Commission, September 20, 2018.

(12 pages)